RESEARCH HIGHLIGHT
Basic Energy Sciences Program
Geosciences Subprogram

Title: Laboratory Method for Investigating Permeability Upscaling

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Objectives: The purpose of this work is to describe, evaluate, and demonstrate a laboratory-based method for physically investigating permeability upscaling.

Results: An instrument, termed the Multi-Support Permeameter (MSP), has been developed for rapid, precise, non-destructive measurement of permeability on heterogeneous blocks of dry rock. The MSP is comprised of an electronic minipermeameter for acquiring permeability data, an x-y positioner for locating and compressing the minipermeameter tip seal against the rock surface, and a computer control system. The unique feature of the MSP is its ability to acquire data with different sample supports while maintaining consistent boundary conditions and flow geometries. Such measurements, spanning almost five-orders of magnitude on a per-volume basis, are made with the MSP by simply varying the size of the permeameter tip seal. The precision and consistency of measurements made in this way were evaluated using a suite of data collected from blocks of three relatively homogeneous materials: Berea Sandstone and two synthetic rocks. Results suggest that measurement error is small (approximately ±1% of the measured permeability) and consistent, and measurements made at different sample supports are free from systematic bias. To demonstrate the ability of this method to measure and quantify upscaling processes, limited data sets were collected with four different-sized tip seals from the Berea Sandstone block. Analysis reveals distinct and consistent trends diagnostic of permeability upscaling relating the sample mean (increased), variance (decreased), and semivariogram to increasing sample support.

Significance: The MSP provides a unique opportunity to physically investigate permeability upscaling. Data acquired with the MSP have the advantages: (1) measurements made at different sample supports are subject to consistent boundary conditions and flow geometries, (2) measurements are spatially exhaustive, (3) orthogonal block faces are sampled, and (4) different rock types are being investigated.

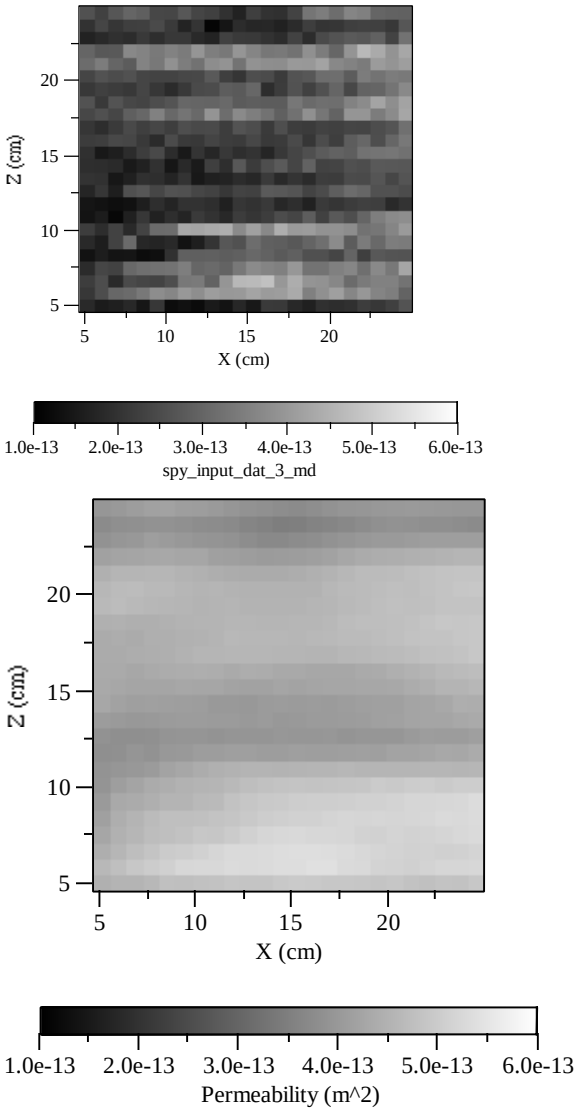

Figure: Gray-scale permeability maps measured with the MSP on a single block face of the Berea Sandstone sample. A 24 by 24 node grid on 0.85 cm centers was used. The top data set was measured with a 0.31 cm ID tip seal while the bottom was measured with a 1.27 cm ID tip seal. Note the distinct smoothing and increased permeability with increasing tip seal size (i.e., sample volume).

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